

Remarks

Claims 1, 3-10, 12-21, 23-25, 27-36 and 38-40 are currently pending. Claims 2, 11, 22, 26 and 37 have been canceled in this amendment without prejudice to pursuing the subject matter of these claims in a further application. Claims 1 and 36 have been amended to specify that the plasma exposure time is between 10 seconds and 1 minute, that the treatment in the second chamber includes exposure to an e-beam or UV radiation and that the additional porogen is removed during this treatment to further increase the porosity of low-k dielectric film. Support for these amendments may be found throughout the specification including in Figure 4A and the associated discussion on page 21, and in originally filed claims 2, 25 and 37.

Claims 1, 5, 7, 15-18, 23, 25, 36 and 38 have also been amended to correct various typographical and syntactic errors and make other minor changes.

The specification has been amended to update application serial numbers and to correct typographical errors.

Objections to the Specification

The disclosure was objected to for containing blanks where serial numbers of applications should be provided. Applicants have amended the specification on pages 1, 3, 16 and 18 to update application serial numbers, and believe these amendments obviate the objections.

Rejections Under 35 USC §112, second paragraph

Claims 1-40 are rejected under 35 USC §112, second paragraph, as being indefinite. Applicants address each of the rejections below:

Claims 1 and 36 were rejected for not having a clear connection between "the precursor film" and the "porous low-k dielectric film." Applicants have amended these claims to specify that the low-k dielectric film is formed by removing precursor from the precursor film and believe this amendment obviates the rejection.

Claim 5 has been amended to delete reference to "silane." Applicants believe this obviates the rejection of the claim for containing an improper Markush group.

With respect to claim 6, Applicants disagree that TMSA (trimethylacetylene) totally encompasses BTMSA (bis-trimethylacetylene). Applicants believe that it is clear that TMSA refers to mono-trimethylacetylene or $\text{Si}(\text{CH}_3)_3\text{C}=\text{CH}_2$, which is mutually exclusive from bis-

trimethylacetylene or $\text{Si}(\text{CH}_3)_3\text{C}\equiv\text{CSi}(\text{CH}_3)_3$. If the Examiner believes it necessary, Applicants propose to amend the claim to recite mono-TMSA.

Applicants have amended claim 8 to correct a typographical error, namely changing "piene" to "pinene." Applicants apologize for the confusion this error appears to have caused and thank the Examiner for the apparent efforts expended in arriving at the correct interpretation of the claim language. Applicants have also amended the specification to correct similar typographical errors.

Applicants have amended claim 16 to clarify that gas modifies hydrogen and nitrogen, i.e., the hydrogen and/or nitrogen sources comprise N_2 and/or H_2 .

Applicants have amended claim 17 to recite "plasma exposure in (b)" rather than "plasma treatment."

Applicants have amended claim 18 to specify that the chamber pressure in question in the chamber pressure of the first chamber, and that it is between 0.5 and 20 Torr. Applicants believe this amendment makes clear that a value somewhere between the claimed values is employed during processing.

Applicants have amended claim 23 to recite that "the first and second chambers are both in the same multi-chamber apparatus." Applicants believe this makes clear that the second of possible interpretations of the Examiner is claimed, and that the reference to first and second chambers in claim 1 indeed requires two different chambers. While Applicants believe that it is clear that claim 1 requires two separate chambers, Applicants propose to further amend the claim if the Examiner believes necessary to clarify this point.

Claims 25 and 38 have been amended to replace "precursor film" with "porous low-k dielectric layer." Applicants believe these amendments clarify the claims and are consistent with the amendments made to claims 1 and 36.

With regard to claims 24 and 36, Applicants believe that it is clear from the specification that "vacuum integrated" refers to the chambers being integrated under a vacuum, i.e., "to prevent wafer exposure to ambient and contaminants between operations" (page 14, lines 10-15). Thus, "integrated" refers to the transfer or area between chambers as being under vacuum, as well as the individual chambers.

Applicants believe the above-described amendment to claim 38, in which "precursor layer" is replaced by "porous low-k dielectric layer" obviates the rejection of claim 38 as lacking antecedent basis for "precursor film."

Applicants believe that these amendments and remarks fully address the rejections under 35 USC §112, second paragraph, and request that the rejections be withdrawn.

Rejections Under 35 USC §112, first paragraph

Claims 8 and 11 are rejected under 35 USC §112, first paragraph, as lacking enablement. With regard to claim 8, applicants have amended the claim to recited pinene, rather than piene. Applicants submit that the claim is now fully enabled. Applicants have canceled claim 11, thus obviating the rejection.

Applicants believe that these amendments and remarks fully address the rejections under 35 USC §112, first paragraph, and request that the rejections be withdrawn.

Non-Statutory Double Patenting Rejections

Claims 1-16, 11, 12, 15-18, 21-24, 26, 27, 32-37, 39 and 40 are rejected on the ground of nonstatutory obviousness-type double patenting over claims 1, 4-8, 11, 12, 25, 26, 30-32, 35 and 37 of U.S. Patent No. 7,166,531. Claims 1-16, 9, 11, 12, 15-24, 26-37, 39 and are rejected on the ground of nonstatutory obviousness-type double patenting over claims 1, 3-7, 10-19, 21 and 23-28 of U.S. Patent No. 7,176,144.

Applicants are submitting a terminal disclaimer over the '531 and '144 patents with this response. As noted in the Action, a timely filed terminal disclaimer may be used to overcome a rejection based on non-statutory double patenting. Accordingly, Applicants request that the rejections be withdrawn.

Rejections Under 35 USC §103

Claims 1-18, 20-24, 26-37, 39 and 40 are rejected under 35 USC §103(a) as being unpatentable over U.S. Patent Publication No. 20040096672 to Lukas et al. (Lukas), or in the alternative, over Lukas in view of U.S. Patent No. 6,268,288 to Hautala et al. ("Hautala"). Claims 19, 25 and 38 are rejected as being unpatentable over Lukas, optionally in view of Hautala, and further in view of one or more additional references.

Applicants have amended the claim 1 to specify that the plasma exposure time in operation (b) is between about 10 seconds and 1 minute, and also to specify that operation (c) further removes additional porogen from the film.

Applicants' claimed invention relates to a process of preparing a strong, low-k dielectric film. As claimed, Applicants' claimed method recites a specific process sequence that results in

optimal properties and high-throughput. Neither the specific sequence of process operations nor the results obtained are taught or suggested by the cited art.

Specifically, the claimed time range results in sufficient quantities of porogen by plasma removed such that subsequent treatment to improve mechanical strength expels reduced quantities of porogen without unnecessarily prolonging the plasma exposure time. As described in the specification with reference to Figure 4A, significant quantities of porogen are removed after 10 seconds. After about 1 minute, however, porogen removal drops precipitously.

The formed dielectric film then undergoes a second treatment, in a second chamber, to remove additional porogen and increase porosity and mechanically strengthen the film. The overall process results in high process efficiency while reducing the amounts of hard to clean porogen expelled during treatment in a UV or e-beam chamber.

At least because the neither a plasma exposure time in operation between about 10 seconds and 1 minute nor a subsequent treatment operation that removes additional porogen from the film are taught or suggested by the cited references, Applicants submit claim 1 is allowable.

Lukas describes two distinct operations: 1) an exposure operation in which pore-former is removed, and 2) a treatment operation in which the mechanical integrity of the network is increased. As noted by the Examiner, the treatment operation may occur before, during or after the exposure operation.

Lukas does not describe or suggest Applicants' claimed range of plasma exposure to remove porogen of 10 seconds to 1 minute. As indicated above, this specific range results in the most porogen removed. Two time ranges relevant to porogen removal and/or plasma treatment are described in Lukas: the exposure step is described as being conducted for "a time of about 60 minutes or less, preferably about 1 minute or less, and more preferably about 1 second or less" (paragraph 57), while plasma treatment is described as occurring from "0.01 min to 12 hours" (paragraph 63). Applicants submit that Lukas does not teach or suggest the claimed optimal range of exposure times with sufficient specificity to anticipate or render obvious the claimed invention. Applicants note for example that the lowest end of the claimed range is 10 ten times the preferred exposure time of less than 1 second in Lukas, while the upper end of the plasma treatment time described in Lukas is 720 times the upper end of Applicants' claimed range.

Lukas also does not teach or suggest a second e-beam or UV treatment to remove additional porogen and increase the mechanical integrity of the film. Specifically, Lukas describes the treatment operation as follows:

The treatment step may increase the mechanical integrity of the material by, for example, promoting cross-linking within the porous film, stabilize the porous film, and/or remove additional chemical species from the network *rather than forming pores*. (paragraph 60, emphasis added).

Thus, while the treatment operation of Lukas may increase mechanical integrity, etc., it does not create additional porosity as the instant claims require. It should be noted that this additional operation is particularly significant for methods in which the initial porogen removal is performed by plasma treatment. Compare Figures 4A and 4B, for example: the inventors found that UV treatment (Figure 4B) removes significantly more porogen than does plasma treatment (Figure 4A). Thus, an additional porogen removal operation may be more salient in cases where the initial porogen removal mechanism is plasma than in cases where the porogen removal mechanism is UV as is emphasized in Lukas.

Hautala does not cure the deficiencies of Lukas. For at least these reasons, Applicants submit that claim 1, and its dependent claims, are patentable over the cited art. Similar amendments were made to claim 36, and Applicants submit that it and its dependent claims are also patentable over the cited art.

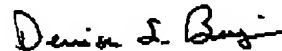
For at least these reasons, Applicants request that the Examiner withdraw these 35 U.S.C. § 103(a) rejections.

Conclusion

Applicants believe that all pending claims are allowable and respectfully request a Notice of Allowance for this application from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the telephone number set out below.

Respectfully submitted,

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